DOCUMENT RESUME

ED 216 871 SE 037 435

AUTHOR Lockett, Danuta Wal
TITLE The Relationship of Classificatory Behavior in Fourth Grade Students to Performance in a Science Education Program at a Museum.
INSTITUTION Creative Associates, Inc., Washington, D.C.
PUB DATE Mar 82
NOTE 18p.; Paper presented at the American Educational Research Association (New York, NY, March 18-23, 1982).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Academic Achievement; *Classification; Cognitive Development; *Developmental Stages; *Elementary School Science; Grade 4; Intermediate Grades; Science Education; *Science Programs; *Student Behavior; Student Characteristics; *Zoos
IDENTIFIERS *Science Education Research

ABSTRACT

Classificatory behavior of 41 fourth graders enrolled in a science program at the National Zoological Park in Washington, D.C. was assessed on an instrument adapted from Piaget's interviews with children on class inclusion. Developmental levels were related to student performance in the program. Data analysis shows that students with a high understanding of class inclusion perform better in the program. The data also support Piaget's finding that a lag exists in children's application of class inclusion to animal classes. The results imply that educators keep in mind the developmental levels of students when planning programs and provide students with opportunities to extend emerging cognitive abilities to new situations. (Author/JN)

**********
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
**********

ED216871

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

# The Relationship of Classificatory Behavior in Fourth Grade Students to Performance in a Science Education Program at a Museum

Danuta Wal Lockett

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Danuta Wal Lockett

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Paper presented at The American Educational Research Association 1982 Annual Meeting

New York

March 19-23, 1982

Author's address: Creative Associates, Inc.
3201 New Mexico Avenue, NW
Washington, DC 20016

SE037435

ABSTRACT

Classificatory behavior of 41 fourth graders enrolled in a science program at the National Zoological Park in Washington, D.C. was assessed on an instrument adapted from Piaget's interviews with children on class inclusion. Developmental levels were related to student performance in the program. Data analysis shows that students with a high understanding of class inclusion perform better in the program. The data also support Piaget's finding that a lag exists in children's application of class inclusion to animal classes. The results imply that educators keep in mind the developmental levels of students when planning programs and provide students with opportunities to extend emerging cognitive abilities to new situations.

One of the many education programs conducted by the National Zoo in Washington, DC is a six-week program developed for fourth graders enrolled in the D.C. public schools. Up to 16 schools can participate on a yearly basis in the program which is known as ZOO ANIMALS: A CLOSER LOOK.

At the beginning of the school year an invitation to all D.C. schools is mailed by the Zoo informing the principals and staff of the program. The teachers at the schools who respond by a given deadline are selected to participate on a first-come-first-serve basis, providing they had not participated in past years. The aim is that the program reach as many new teachers and schools as possible.

In the 1979-1980 school year, the program was in its third year of operation. Based on informal evaluations and comments, the program appeared to be popular with the participants and the volunteers who had specially trained to teach it. The education staff at the National Zoo, however, wanted to formally evaluate the program's accomplishments in the affective and cognitive areas. One program goal selected for the evaluation was to determine how well students had learned the zoological classification system and the characteristics of animals within the vertebrate class.

In the process of designing an evaluation instrument the education staff hypothesized that learning about the zoological classification system may depend on understanding the inclusiveness of classes within a hierarchical structure. The animal hierarchy, for example, is comprised of several parts or groups, and that within the vertebrate group there are the subgroups of reptiles, amphibians, birds and mammals.

The ability to reason about the inclusiveness of classes emerges during the stage of concrete operations, according to Jean Piaget, at approximately 7 or 8 years of age. Class inclusion reasoning involves the ability to relate the parts of a class to the whole. According to Piaget, the relation between classes is a function of two kinds of mental operations -- the union of subclasses to form the whole (A + A' = B) and the taking away of a subclass from the whole (B - A = A'). Piaget also observed that children apply class inclusion reasoning later to animals than to geometric shapes and to flowers.

On the basis of Piaget's writings, the education staff was interested in finding out, (a) whether children enrolled in the ZOO ANIMALS program exhibit class inclusion reasoning; (b) whether a systematic lag occurs in applying class inclusion reasoning to geometric shapes first then to animals; and (c) whether class inclusion reasoning is a prerequisite to successful learning of the zoological classification system.

The literature was examined to find out at what age class inclusion reasoning emerges, what may account for the systematic lag in development of class inclusion reasoning, and whether the relationship of class inclusion reasoning to performance in a science curriculum has been examined previously.

In a review of the empirical literature on class inclusion, Winer (1980) found a majority of studies report development of class inclusion reasoning later than the 7-8 years predicted by Piaget. The exact age when class inclusion reasoning appears, however, is not clear from the research. It seems to develop across a wide range of ages. One third of the studies reviewed by Winer show that class inclusion reasoning emerges early. As an example, a group of studies (Elkin, 1961; Jamison, 1977; Markman, 1978; Smedslund, 1964;

Tatarsky, 1974; Wei, Lavatelli & Jones, 1971; and Winer, 1974) demonstrate that 75% of the 7-8 year olds tested answered the class inclusion questions successfully which is in contrast to the remaining two-thirds of the studies reviewed by Winer which show later development.

Winer found that early development could largely be accounted for by variations in testing procedures. Factors like increasing the use of tangible materials, asking questions prior to administration of the test, and varying questions from the standard format were likely to affect performance and accelerate the appearance of class inclusion reasoning.

Changing the typical class inclusion question from the standard-type item taken from Piaget (e.g., "Are there more dogs or more animals") facilitated performance on class inclusion tests in a number of cases, thus contributing to a higher level of success at an earlier age. Shipley (1979) found, for example, that performance was facilitated by providing linguistic cues and changing the question to, "Which is more, only the lemons or all the fruit." In her study, Markman (1978) showed that children found the class inclusion question easier when a collective noun like family was used instead of a class noun. A sample question is, "Who would have more, someone who owned the baby dogs or someone who owned the family." Other examples of variations in wording of the class inclusion question which were found to affect performance are: (a) omitting the relational conjunction "or" as in the question, "Are there more horses than there are animals? (Brainard & Kaszor, 1974); (b) omitting the relational term "more" as in the question, "Do you want to eat the smarties or the candies." (Siegel et al, 1978); and (c) using the word "all" to modify the superordinate class (Hodkin, 1981).

The verbal cues can facilitate performance and account for some of the variation reported in the research on the age when class inclusion emerges.

Piaget alludes to a systematic lag in the application of class inclusion reasoning to various objects. When testing children on class inclusion, Piaget varied the questions to include geometric shapes, flowers and animals. The children's responses indicated that they found the class inclusion questions easier when working with geometric shapes than with flowers or animals. Piaget (1964) reasoned that a systematic lag occurs because children have had more experience collecting and grouping geometically shaped objects and flowers than animals at the time of testing. Animals, Piaget said, "are more remote from everyday experience and therefore more abstract" (p.110).

A review of the literature shows that few studies have examined the reason for this systematic lag. Kohnstamm (1963) and Ahr & Youniss (1970) were unable to replicate Piaget's findings that a systematic lag occurs in applying class inclusion reasoning to animals. Carson and Abramson (1976) observed that the items used by Kohnstamm, Ahr & Youniss contained mammals as the animal exemplars unlike the questions used by Piaget which included nonmammal exemplars (e.g., ducks and other birds). Carson and Abrahamson reason that differences in performance are semantically based in the choice of exemplars for the test item. Mammals are considered typical exemplars of the animal class rather than nonmammals. They predicted that children would perform better on questions which include typical rather than atypical exemplars. The results of their investigation support their predictions, again showing the extent to which semantics can affect performance on class inclusion tasks.

The evidence in the research literature, therefore does not seem to clearly support a systematic lag in the application of class inclusion reasoning to different kinds of content on the basis of familiarity or abstractness of the objects used in the classification tasks.

A search of the literature indicates that the relationship of class inclusion to performance in a science program has not been examined directly to date. In a study of the development of hierarchical classification ability, Lovell (1980) suggests the importance of classification reasoning in learning science. He states, "The ability to organize information into hierarchical classes is essential to learning the complex logical relations in all scientific disciplines" (p.425). The ability to classify hierarchically is a prerequisite, Lovell (1979) reasons, to the ability to reason abstractly. This supports Piaget's claim that understanding class inclusion is a prerequisite to the development of formal operations. Lovell (1980) found that the ability to classify hierarchically begins to develop around 11-12 years of age and does not develop fully until mid-adolescence, around age 14. In view of this evidence, Lovell suggests that abstract scientific curricula may not be appropriate in junior high and high school contrary to impressions some educators may have because adolescents continue to rely on concrete cues while reasoning about classification.

In conclusion, the review of the literature showed that the education staff was not unreasonable in pursuing a study which would answer the following questions as they pertain to the student population enrolled in the Zoo program:

1. Do children enrolled in the fourth grade who participate in the Zoo program exhibit class inclusion reasoning?
2. Do the children apply class inclusion reasoning more easily to questions about geometric shapes than to animals?
3. Is class inclusion reasoning a prerequisite ability to successful performance in the Zoo program?

It was not possible to examine these questions extensively because the major thrust was an overall evaluation of performance in the Zoo program. Thus, this study could only be exploratory in nature. There were limits on time, the test would

have to be squeezed in during testing for the evaluation. Only a small population of students would be available to test. Thus, the questions examined in this study related more closely to the Zoo experience. The results, however, would have direct implications on program development and would relate to the larger purpose of the evaluation study which was to make suggestions for improvement in future years.

Forty-one fourth grade students (mean age 10 years) from two of the four schools participating in the evaluation of the program were selected to participate in this study. The two schools were selected because they represented the high and low socio-economic levels of the four schools involved in the evaluation. Based on demographic data gathered for all the other schools participating in the program during the 1979-1980 academic year, the four schools which participated in the evaluation study were representative of the population which attended the program that academic year. Specifically, the evaluation test sample was almost evenly distributed by sex, a majority were classified as reading on grade level and most of the sample had had previous experience at the Zoo.

Two tests were administered to the class inclusion sample population. One was the program test designed to assess the affective and cognitive performance of the students after participation in the program. Only the portion of that test which examined student's knowledge of the hierarchical classification of animals and their characteristics was used in this analysis.

The second test administered was on class inclusion using similar items to ones used by Piaget in his original research. The major difference is that the test used in this study was an objective test whereas Piaget gathered data in interviews with subjects. Section I of the test contained drawings of five striped circles, two striped squares, and two black squares. Based on

their observation of the drawings the children were asked to answer yes or no to questions such as, "Are all the squares black?" In section II of the test, students were asked to answer questions which were based on drawings of three ducks, four birds (other than ducks), three animals (other than birds) and three inanimate objects (a tea cup, clock and car). A sample question from this section is, "If all the animals died, would there be any birds left?"

The data was examined for indication of class inclusion reasoning, the application of class inclusion reasoning to two different classes of objects, and the relationship of class inclusion reasoning to performance in the Zoo program.

The distribution of test scores by percentage is shown in Table 1. Test scores were classified as low, medium, and high. Examination of the data indicates that class inclusion reasoning emerges during fourth grade for the students tested. Furthermore, the distribution of scores reveals that the highest percentage of students show a "moderate" level of class inclusion reasoning (54.5%). Approximately the same number of students show a low and high level of reasoning. Only 7% of the students tested scored 50% or less on the test. This distribution of scores indicates that class inclusion reasoning has emerged for the population tested but not at the highest level. Mastery of class inclusion has not occured for most of the students tested.

Insert Table 1 here

These findings concur with studies which report development of class inclusion later than the 7-8 years predicted by Piaget. Furthermore, it suggests that children at age 10 have not yet mastered class inclusion reasoning. Lovell (1980) for example, showed the hierarchical classification reasoning begins to develop at around 11-12 years but is not fully developed until mid-adolescence, a time when most children demonstrate some level of formal reasoning.

TABLE 1

Percentage of Students in each
Category of Scores
on the Class - Inclusion Test

| | Low | | | | Moderate | | High | |
|---|---|---|---|---|---|---|---|---|
| Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| % | 2.5 | 0 | 5 | 15 | 41 | 17 | 17 | 2.5 |
| Cummulative % | 2.5 | 2.5 | 7.5 | 22.5 | 63.5 | 80.5 | 92.5 | 100 |

Test scores on both parts of the classification test were compared. Questions in Part I pertain to geometric shapes and Part II to animals. The results show that 68% of the students scored higher on Part I of the test than Part II. Five percent of the students tested showed no difference in test performance on both sections and 27% attained lower scores on Part II than Part I of the test.

These results support Piaget's findings that class inclusion reasoning is more easily applied to geometric shapes than to animals. Piaget explains that familiarity with the objects affects class inclusion reasoning. For example, children have had more experiences manipulating geometric shapes than animals. No studies were found by this investigator to support Piaget's claim that object familiarity causes a systematic lag in performance. The results of this study question the factor of familiarity since the classification test was administered 3 weeks into the 6 week program at a time when the participants had been exposed to each of the animal categories and had the chance to directly observe, or manipulate some animals. Thus, the content of the class inclusion test question seems to affect performance but factors other than familiarity most probably account for the difference in performance.

Finally, levels of class inclusion reasoning were compared to levels of performance on the program test. Scores on the program test were grouped as high (42 points and above -- 45 points was the highest possible) or low (41 points and below). The scores on both tests were cross-tabulated (Table 2) to determine whether students who showed a high level of class inclusion reasoning also attained high score on the program test. The distribution of scores show that students who scored low on the class inclusion test scored low on the program test. Those students who scored high on the class inclusion test tended to score high on the program test. The students who demonstrated moderate class inclusion reasoning were equally distributed in the high and the low categories on the program test.

Insert Table 2 here

A chi-square analysis reveals that the distribution of observed cell frequencies differed significantly from expected cell frequencies at the $p < .07$ level, which approaches but does not reach significance at the $p < .05$ level. Even though the results did not achieve significance, the percentages within the cells indicate a pattern which deserves attention and warrants further study in the context of examining the relationship of emerging cognitive skills viewed to the development and evaluation of educational curriculum. Since this study was a supportive and secondary aspect to the main evaluation of the Zoo's fourth grade program, the number of students tested was not sufficient to fill out the extreme ends of the distribution of test scores. Low cell frequencies in the upper and lower ranges of the distribution affect chi-square analysis. Because the sample was restricted in age and because the developmental trend being examined is also related to age, a high number of cases were found in the middle categories and few in tne extreme ends of the disbribution. Future analysis of this kind should include a larger sample which should increase the likelihood of obtaining diverse scores.

The results indicate that since all students tested demonstrated class inclusion reasoning at some level, but few at the highest level, students at this age (mean age of 10 years) are receptive to class inclusion activities and to a curriculum designed with information arranged in a hiearchical manner. However, since it is an emerging skill, students would seem to be in a better position to understand the zoological classification system, for example, if they were given preliminary activities and practice in forming their own hierarchical classification systems.

The results also show that classification of objects, like geometric shapes, is easier than other objects, like animals. The reason for this is not

TABLE 2

Class - inclusion Ability of Students with
Low and High Cognitive Test Scores

| Cognitive Posttest | Class-inclusion Test | | | |
|---|---|---|---|---|
| | Low 6 and Below | Moderate 7-8 | High 9-10 | Row Total |
| Low 41 and below | 6 (14.6%) | 12 (29.3%) | 1 (2.4%) | 19 (46.3%) |
| High 42 and above | 3 (7.3%) | 12 (29.3%) | 7 (17.1%) | 22 (53.7%) |
| Column total | 9 (22%) | 24 (54.5%) | 8 (19.5%) | 41 (100%) |

$x^2 = 5.31$

$p < .07$

clearly established in this study. Therefore, the Zoo, or any other education group, should expect that at the time most children enter the program they may understand class inclusion at some level, but may not be able to apply it necessarily to the content of the program such as the zoological classification system. Again, the data suggest the importance of giving children repeat experience in classification and class inclusion to extend their understanding of class inclusion to a variety of subject areas and objects. David Elkind (1970 ) refers to this as "horizontal elaboration". He states, "In general, a child who elaborates the skills he does have, such as the ability to order materials according to size, on a wide range of different materials (blocks, sticks, dolls, dogs, and so on), is likely to be better prepared for future learning than a child who has learned a great deal in a short time but who has not really had the opportunity to assimilate and practice what he has learned" (p. 55).

Finally, a relationship does appear to exist although statistically weak between class inclusion reasoning and learning in the Zoo program about the classes of animals and characteristics related to them. The pattern of percentages within the categories of scores suggest that children who have developed the ability to classify animals hierarchically increase the likelihood of successfully learning about zoological classes and related animal characteristics.

In conclusion, these results show the importance of considering a child's developmental level in the development and evaluation of an education program, whether it is conducted in a traditional or non-tradition setting, such as zoos and museums. Furthermore, performance in a program which demands a certain cognitive ability, such as class inclusion, may be enhanced by providing students with the opportunity to extend their emerging abilities to new

situations. Educators thus should allow children to experience their growth potential to the fullest extent possible.

BIBLIOGRAPHY


Ahr, P.R., & Youniss, J. Reasons for failure on the class - inclusion problem. Child Development, 1970, 41, 131-143.

Brainerd, C.J., & Kaszor, P. An analysis of two proposed sources of children's class - inclusion errors. Developmental Psychology, 1974, 10, 633-643.

Carson, M.T., & Abramson, A. Some members are more equal than others: The effect of semantic typicality on class - inclusion performance. Child Development, 1976, 47, 1186-1190.

Elkind, D. Children and Adolescents, NY: Oxford University Press, 1970.

Elkind, D. The development of the additive composition of classes in the child: Piaget's replication study III. Journal of Genetic Psychology, 1961, 99, 51-57.

Fourmanek, R. & Gurian, A. Charting intellectual development. Springfield, Illinois: Charles C. Thomas, 1976.

Hodkin, B. Language effects in assessment of class - inclusion ability. Child Development, 1981, 52, 470-478.

Inhelder, B., & Piaget, J. The early growth of logic in the child: Classification and seriation. New York: Norton, 1964.

Jamison, W. Developmental inter-relationships among concrete operational tasks: An investigation of Piaget's stage concept. Journal of Experimental Child Psychology, 1977, 24, 235-253.

Kohnstamm, G.A. An evaluation of part of Piaget's theory. Acta Psychologica, 1963, 21, 313-356.

Lovell, W.E. The development of hierarchical classification skills in science. Journal of Research in Science Teaching, 1980, 17 (5), 425-433.

Lovell, W.E. A study of hierarchical classification in concrete and abstract thought. Journal of Research in Science Teaching, 1979, 16 (3), 255-262.

Markman, E. The facilitation of the part-whole comparisons by use of the collective noun "Family". Child Development, 1973, 44, 837-840.

Shipley, E.F. The class - inclusion task: Question form and distributive comparisons. Journal of Psycholinguistic Research, 1979, 8, 301-331.

Siegel, L.S., McCabe, A.E.; Brand, J. & Matthews, J. Evidence for the understanding of class inclusion in preschool children: Linguistic factors and training effects. Child Development, 1978, 49, 689-693.

Smedslund, J. Concrete reasoning: A study of intellectual development. Monographs of the Society for Research in Child Development, 1964, 29 (2, Serial No. 93).

BIBLIOGRAPHY con't

Tatarsky, J.H. The influence of dimensional manipulations on class inclusion performance. Child Development, 1974, 45, 1173-1175.

Wei, T.T.D., Lavatelli, C.B., & Jones, R.S. Piaget's concept of classification: A comparative study of socially disadvantaged and middle-class young children. Child Development, 1971, 42, 919-927.

Winer, G.A. Class - inclusion reasoning in children: A review of the empirical literature. Child Development, 1980, 51, 309-328.

Winer, G.A., & Krenberg, D.D. Children's responses to verbally and pictorially presented class - inclusion items and to a test of number conservation. Journal of Genetic Psychology, 1974, 125, 141-152.